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Ernstson et al.

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(54) **WORM GEAR FOR A WORM GEAR SYSTEM IN A MOTOR VEHICLE STEERING DEVICE HAVING AN INJECTION-MOULDED SUPPORT RING**

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B29C 45/14 (2006.01)
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(Continued)

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CPC F16H 2055/065; F16H 55/06; B29C 45/14491; B29L 2015/003
See application file for complete search history.

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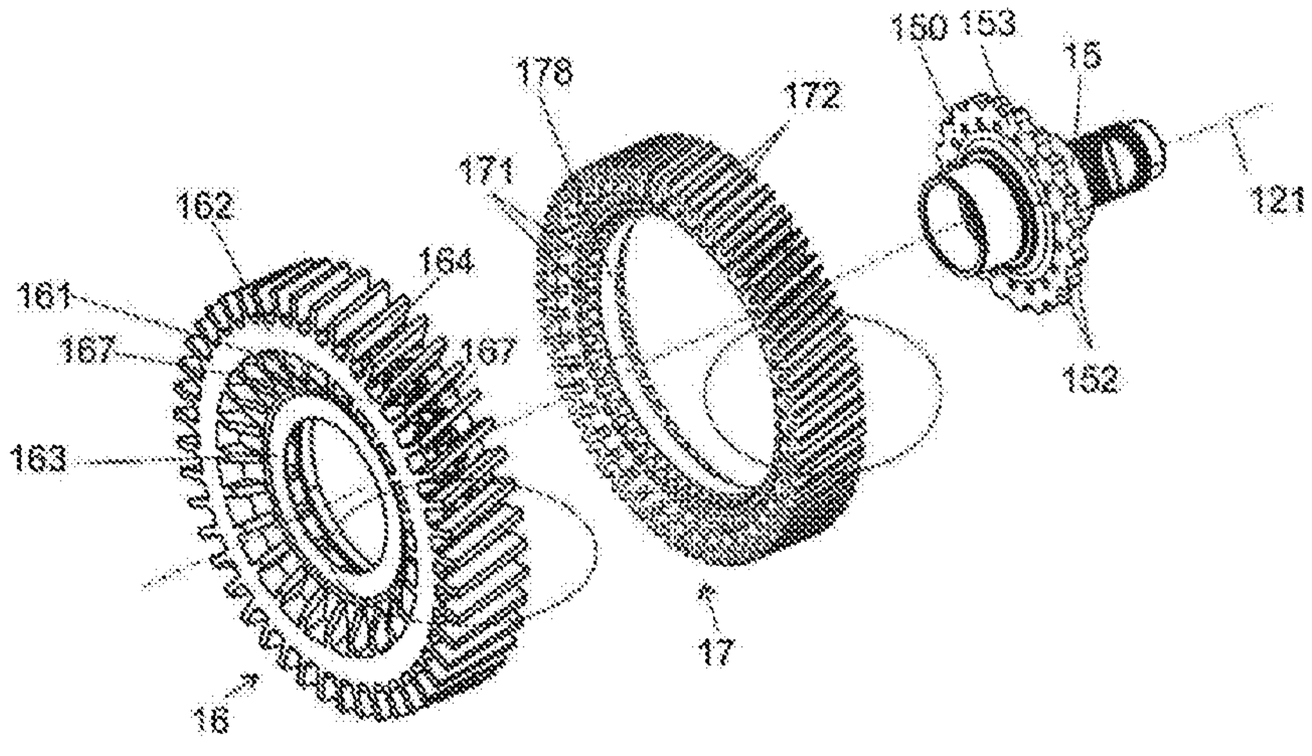
(57) **ABSTRACT**

A worm gear for a worm gear system of a motor vehicle steering device may include a hub, a support element, and a gear rim. The support element may be a support ring that by means of an injection-molding method is injected between the gear rim and the hub. The support ring may connect in a form-fitting manner the hub and the gear rim. The gear rim and the support element may configure a multiplicity of teeth. The support element may have support webs that penetrate the gear rim such that radially outward pointing end sides of the support webs are exposed.

17 Claims, 3 Drawing Sheets



(51) **Int. Cl.**

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F16H 55/22	(2006.01)
B29L 15/00	(2006.01)
B62D 5/04	(2006.01)
B29L 31/30	(2006.01)

(52) **U.S. Cl.**
CPC ***F16H 1/16*** (2013.01); ***F16H 55/22*** (2013.01); *B29C 2045/1454* (2013.01); *B29L 2015/003* (2013.01); *B29L 2031/30* (2013.01); *F16H 2055/065* (2013.01)

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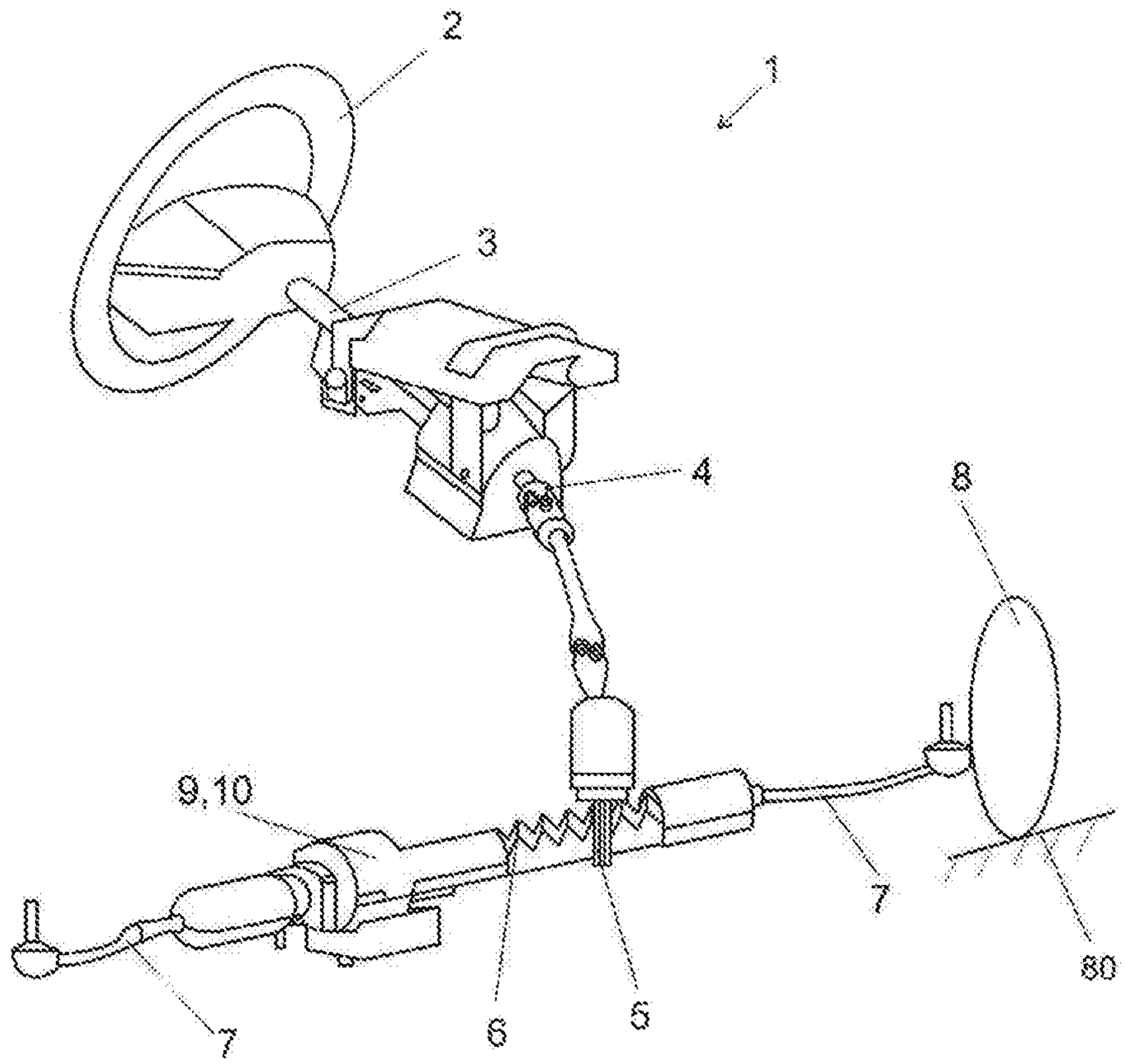


Figure 1

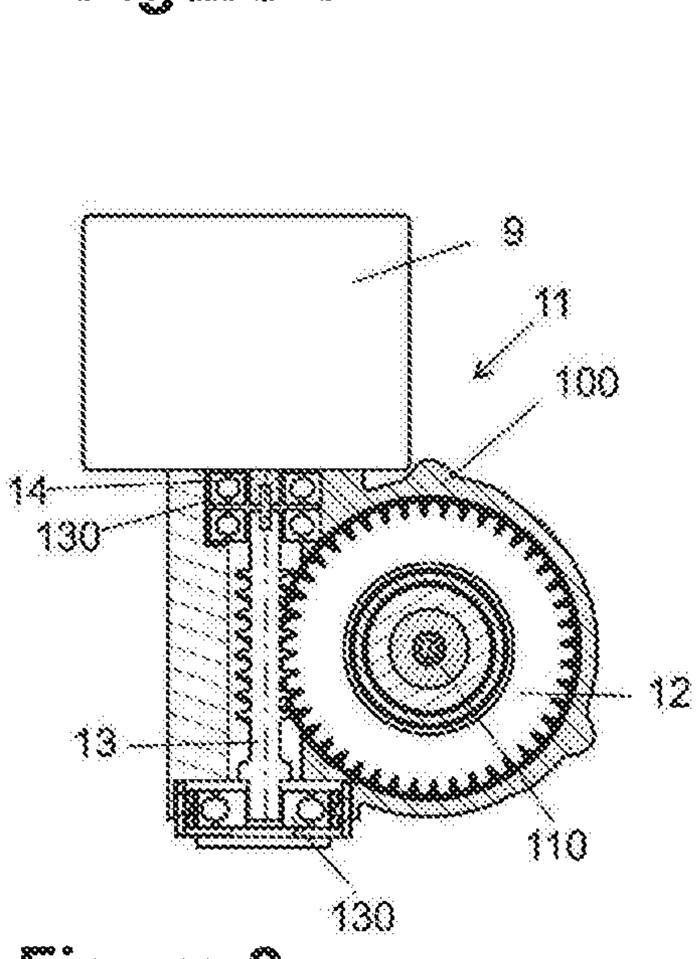
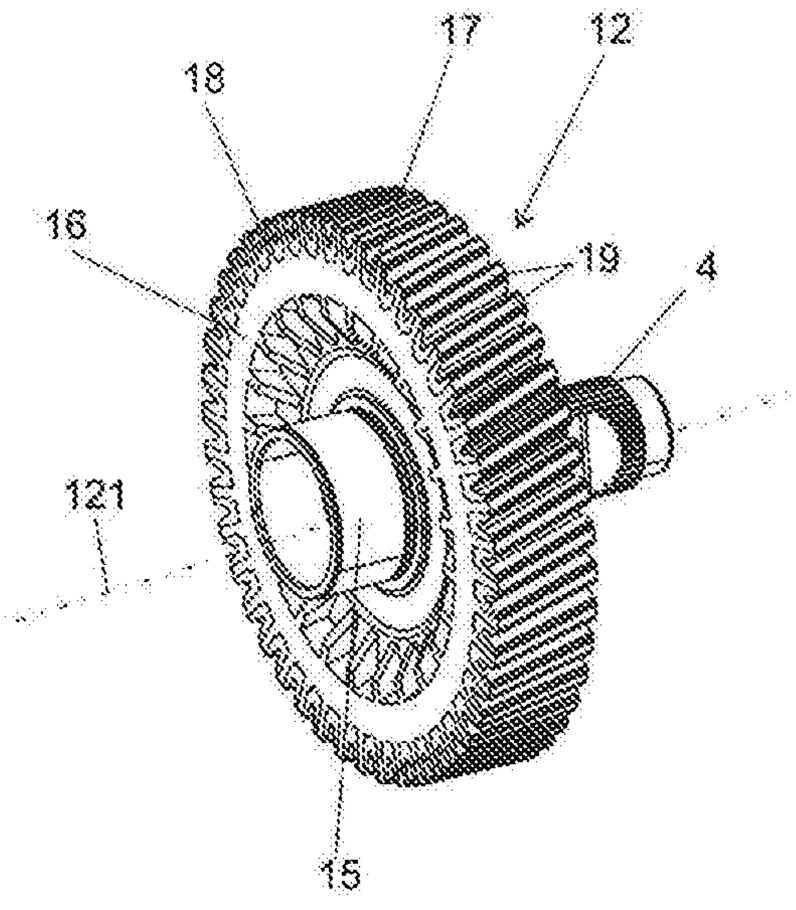


Figure 2



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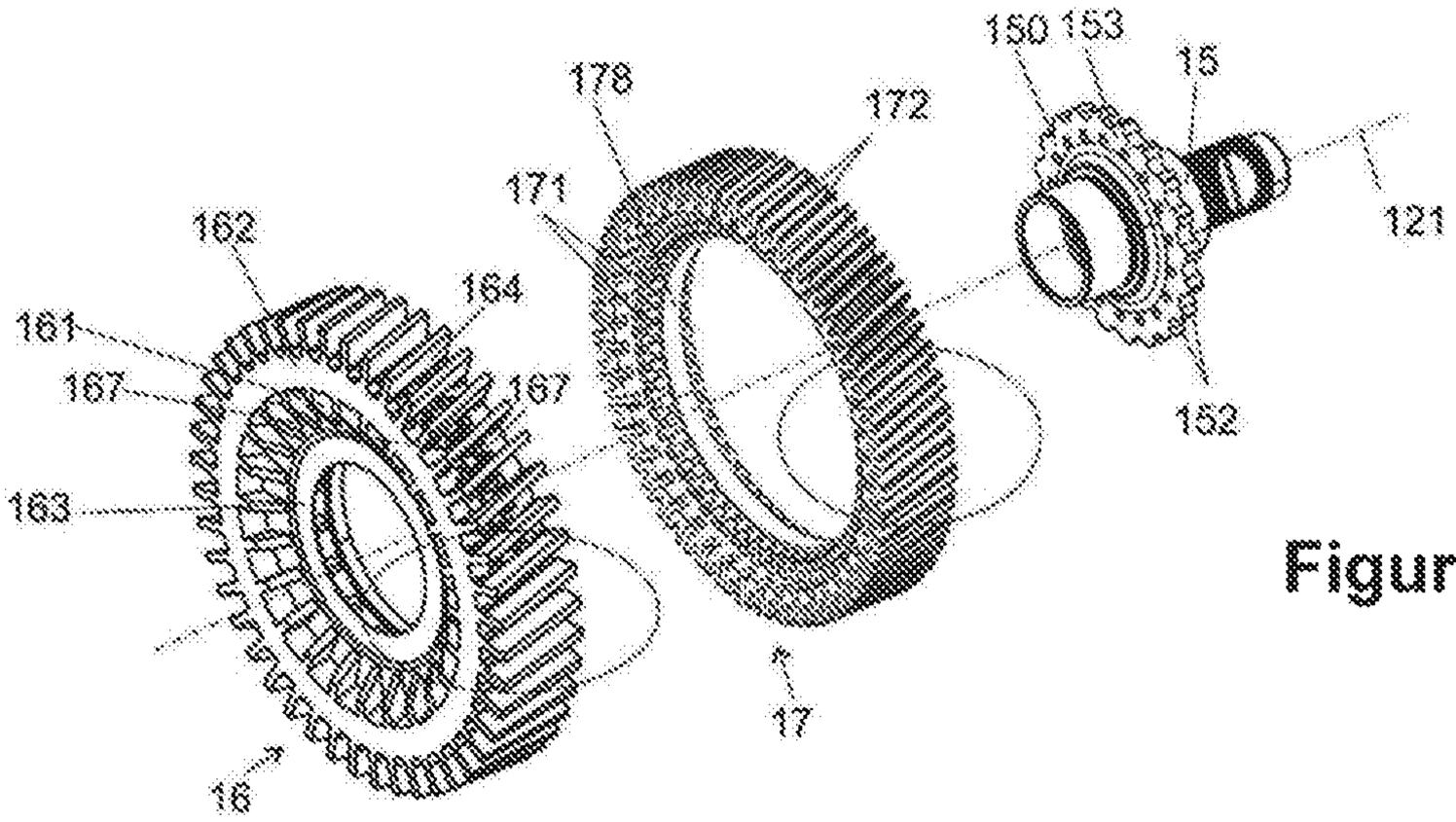

Figure 4

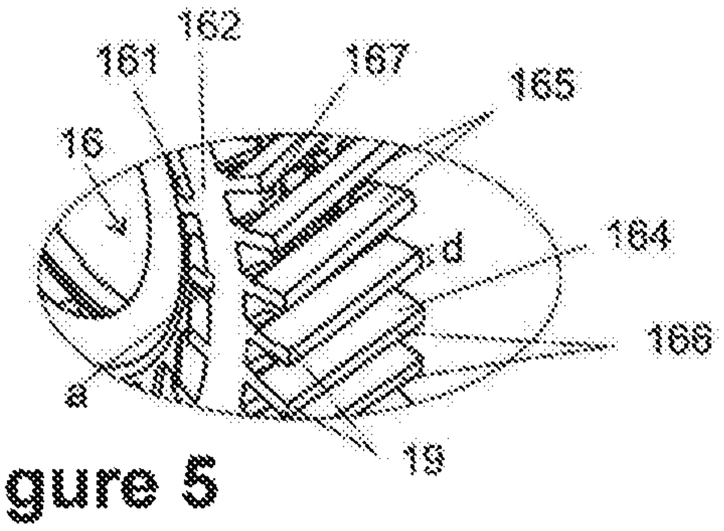

Figure 5

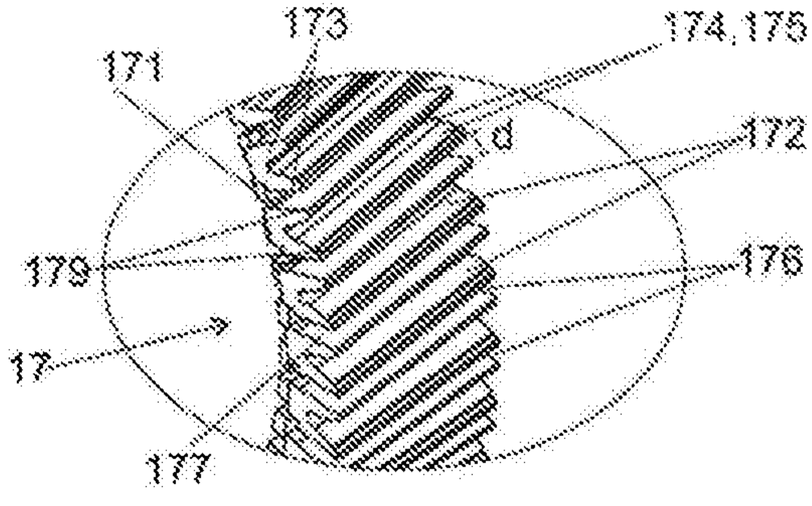

Figure 6

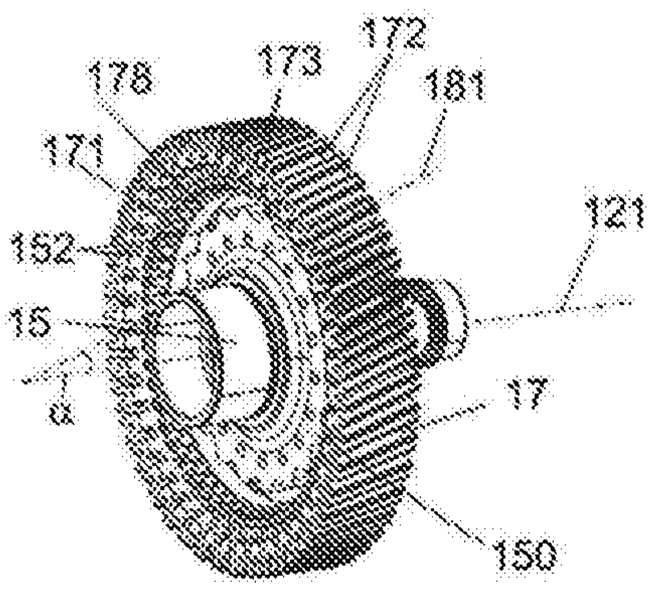

Figure 7

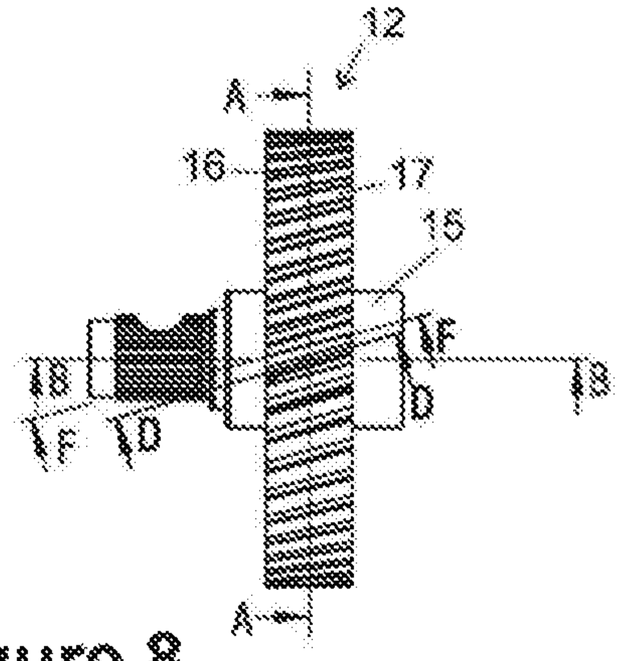

Figure 8

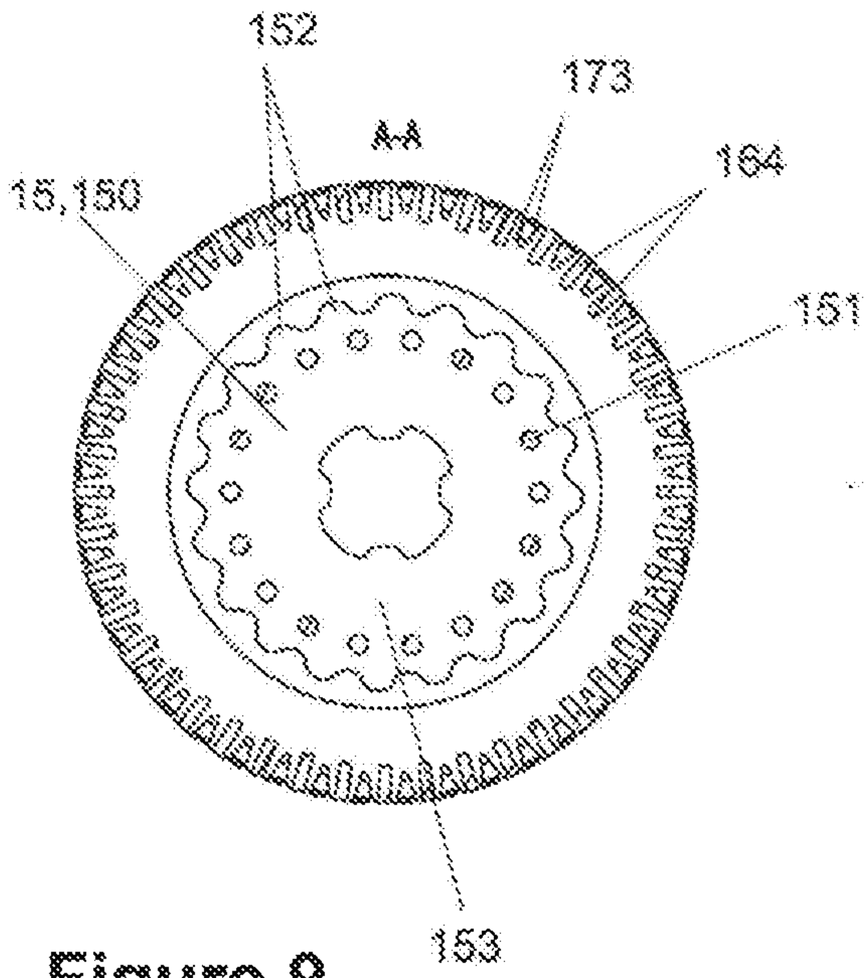

Figure 9

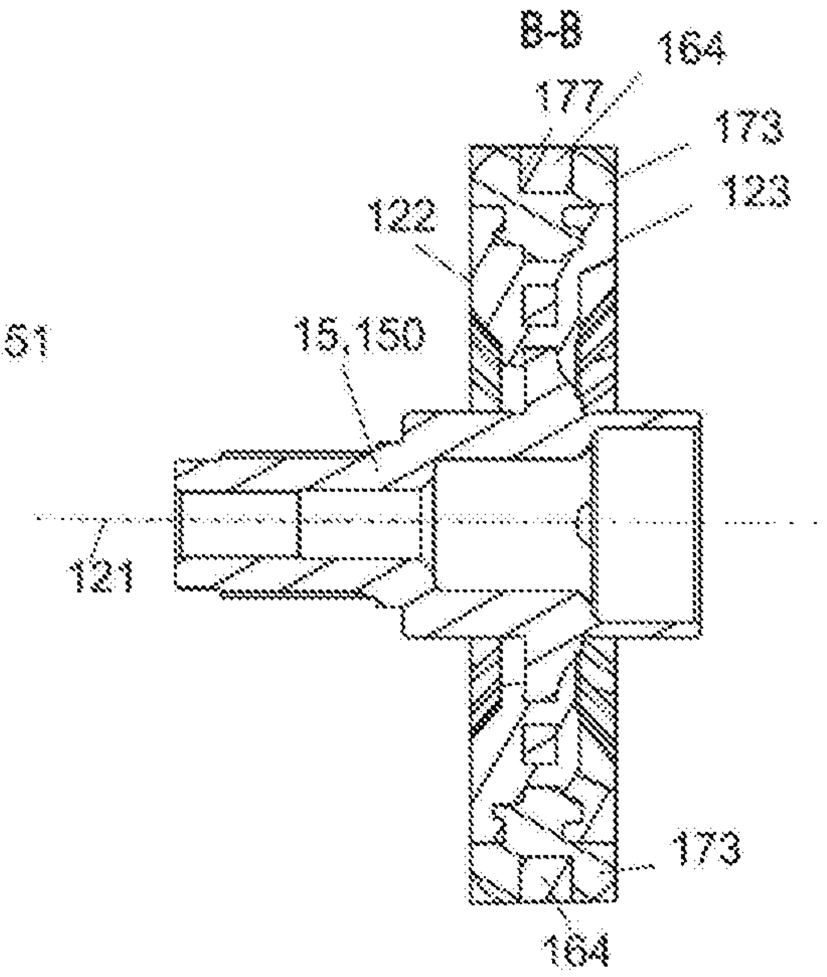

Figure 10

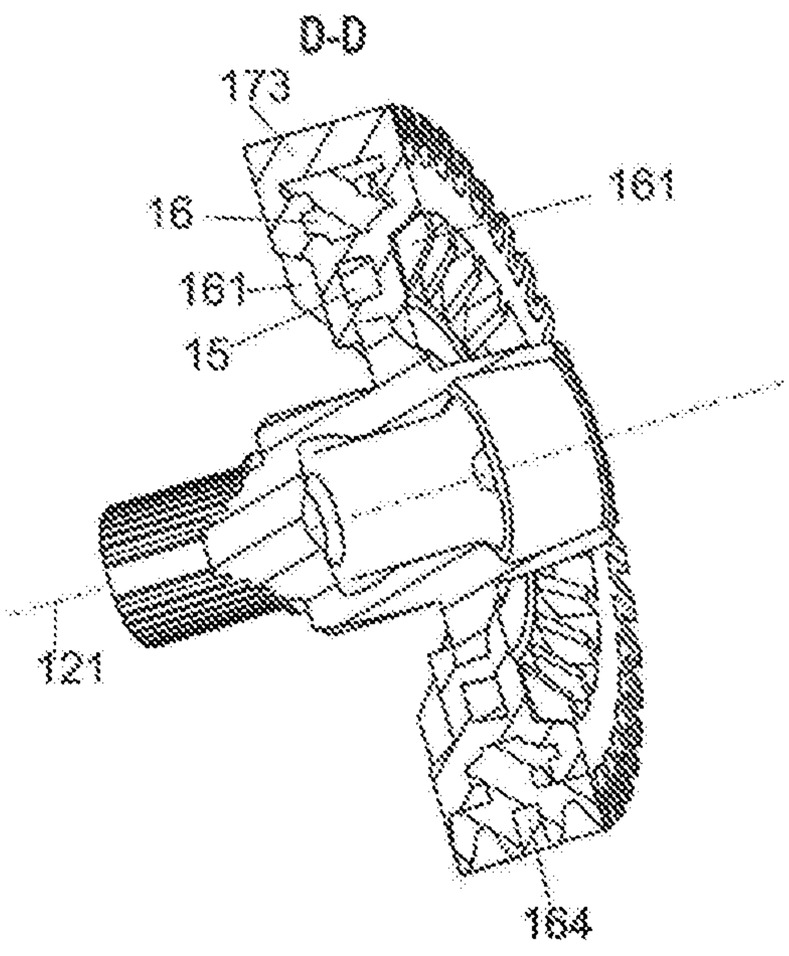

Figure 11

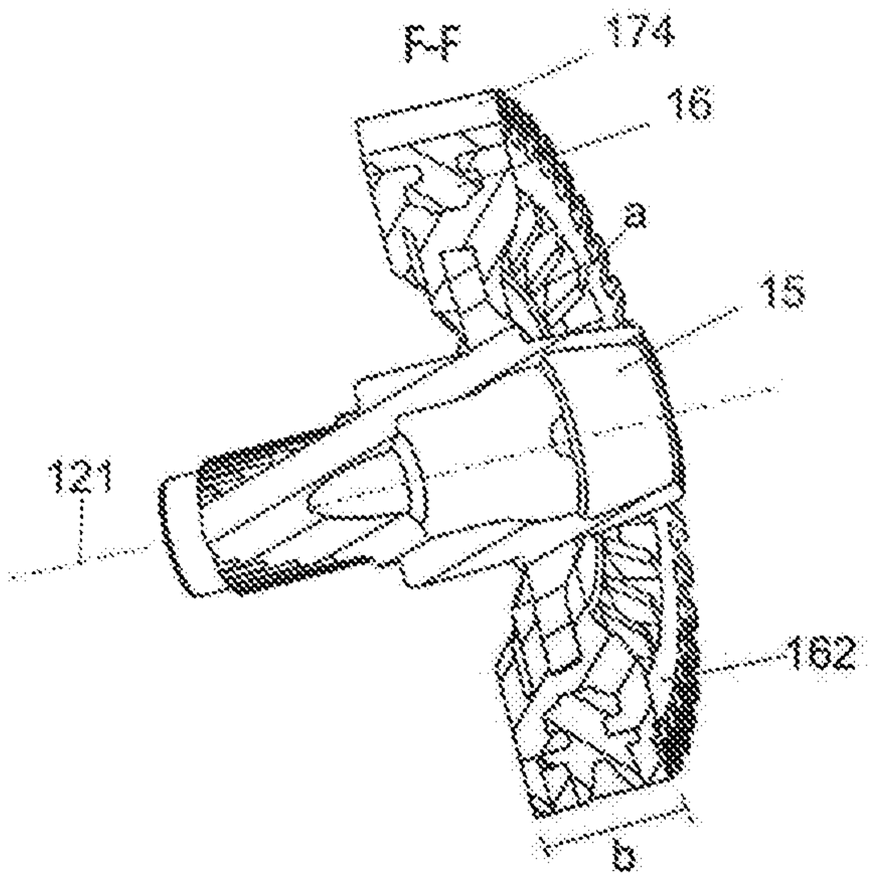

Figure 12

WORM GEAR FOR A WORM GEAR SYSTEM IN A MOTOR VEHICLE STEERING DEVICE HAVING AN INJECTION-MOULDED SUPPORT RING

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a U.S. National Stage Entry of International Patent Application Serial Number PCT/EP2018/085647, filed Dec. 18, 2018, which claims priority to German Patent Application No. DE 10 2017 131 180.7, filed Dec. 22, 2017, the entire contents of both of which are incorporated herein by reference.

FIELD

The present disclosure generally relates to steering systems, including worm gears and worm gear systems of motor vehicle steering devices.

BACKGROUND

Gear systems which transmit an auxiliary torque from an electric motor to a steering shaft are inter aha required in the use of electro-mechanical power-assisted steering devices. The electric motor usually drives a worm which engages with a worm gear which is disposed in a rotationally fixed manner on the steering shaft or on a pinion.

The worm gear comprises an insert which is connectable in a rotationally fixed manner to the steering shaft or to the pinion, wherein said insert is enhanced with a plastics material. Said plastics material configures the so-called gear rim.

Worm gear systems are exposed to shock-type stress on account of which the forces generated by the maximum torque on the tooth flanks in normal operation lead to excessive stress. The tooth flanks are in particular highly sensitive to said shock-type stress.

A multiple-part gear wheel in which a connection part connects a hub to a gear rim is known from the first and unexamined publication DE 10 2014 104 284 A1. The connection part herein encloses the gear rim toothing in portions in the region of the end face.

This solution has proven disadvantageous in that a non-uniform distribution of force is created in the region of the engagement between the worm and the worm gear, on account of which more rapid abrasion of the worm gear system and thus more rapid wear is facilitated.

Thus a need exists for a worm gear for a worm gear system of a motor vehicle steering device which by way of ideally simple means enables an improved distribution of force in the engagement between the worm and the worm gear, thus enabling the transmission of higher torques.

BRIEF DESCRIPTION OF THE FIGURES

FIG. **1** is a schematic view of an example electro-mechanical motor vehicle steering device.

FIG. **2** is a cross-sectional view through an example worm gear system.

FIG. **3** is a spatial view of an example worm gear.

FIG. **4** is an exploded view of the worm gear.

FIG. **5** is a detail view of an example support ring of the worm gear.

FIG. **6** is a detail view of an example gear rim of the worm gear.

FIG. **7** is a spatial view of the worm gear without the support ring.

FIG. **8** is a top view of the example worm gear.

FIG. **9** is a cross-sectional view through the worm gear along line A-A.

FIG. **10** is a longitudinal sectional view through the worm gear along line B-B.

FIG. **11** is a sectional view through the worm gear along line D-D.

FIG. **12** is a sectional view through the worm gear along line F-F.

DETAILED DESCRIPTION

Although certain example methods and apparatus have been described herein, the scope of coverage of this patent is not limited thereto. On the contrary, this patent covers all methods, apparatus, and articles of manufacture fairly falling within the scope of the appended claims either literally or under the doctrine of equivalents. Moreover, those having ordinary skill in the art will understand that reciting "a" element or "an" element in the appended claims does not restrict those claims to articles, apparatuses, systems, methods, or the like having only one of that element, even where other elements in the same claim or different claims are preceded by "at least one" or similar language. Similarly, it should be understood that the steps of any method claims need not necessarily be performed in the order in which they are recited, unless so required by the context of the claims. In addition, all references to one skilled in the art shall be understood to refer to one having ordinary skill in the art.

The present disclosure generally relates to a worm gear for a worm gear system of a motor vehicle steering device, to a worm gear system for a motor vehicle steering device, as well as to a method for producing a worm gear for a worm gear system of a motor vehicle steering device.

Accordingly, a worm gear for a worm gear system of a motor vehicle steering device, comprising a hub, a support element, and a gear rim is provided, wherein the support element is a support ring which by means of an injection-molding method is injected between the gear rim and the hub and which connects in a form-fitting manner the hub and the gear rim. The gear rim and the support element configure a multiplicity of teeth, wherein the support element has support webs which penetrate the gear rim such that the radially outward pointing end sides of the support webs are exposed. The term "exposed" here is to be understood that the end sides are not covered by the gear rim, or that the gear rim does not protrude beyond said end sides, respectively. The support webs distribute the force which in the event of stress acts on the toothing. A transmission of higher torque is enabled on account thereof.

The height of the support webs of the support element advantageously corresponds to the height of the teeth of the gear rim.

The gear rim preferably has tooth elements which configure the tooth flanks of the teeth. It is preferable herein for one tooth element to configure in each case one tooth flank of two neighboring teeth. In this case it is advantageous for the support webs of the support element to be in each case disposed between two flanks of one tooth. The support webs thus lie between two tooth elements. One tooth of the worm gear is thus formed by two tooth elements and one support web. The force acting on the toothing herein is absorbed not only by the support web but also by the two tooth elements

adjacent to said support web. One tooth element preferably configures in each case one tooth flank of two neighboring teeth.

In one preferred embodiment, the support webs extend across the entire width of the worm gear in the region of the teeth. The force can thus be distributed in the best possible manner. Instead of a support web which penetrates the complete width, it is furthermore conceivable and possible for a support web which does not have the complete width of the tooth to be formed. It is furthermore possible for two support web arms to penetrate in each case part of the tooth width and for said two support webs to be in each case mutually spaced apart by a gap.

The support webs preferably have a consistent width. In one further advantageous embodiment, the support webs have a profile or undercuts, this leading to greater stresses.

The support webs from an annular web of the support element preferably extend outward in the radial direction.

The gear rim is preferably a single-component plastics-material part which is preferably formed from a tough material. In contrast, the support ring is preferably formed from a high-density, highly-oriented plastics material. The gear rim and/or the support ring are/is preferably composed of artificial resin or a thermoplastic material, in particular of polyamide, polyoxymethylene, saturated polyester, polyether, and/or ether ketone, or comprises reinforcement fibers or a fiber-reinforced plastics material.

The insert part preferably has injection bores which are configured for injecting a plastics material for configuring the support ring.

The support ring preferably has undercuts which in the production permit jamming between the support ring and the gear rim.

Furthermore provided is a worm gear system for a motor vehicle steering device, having a worm gear as described above and having a worm which engages with the worm gear.

Moreover provided is a method for producing a worm gear for a worm gear system of a motor vehicle steering device, comprising a hub, a support element, and a gear rim, said method comprising the following steps:

providing the hub in the form of an insert part;

inserting the insert part into the gear rim;

injecting a plastics material between the gear rim and the insert part by means of an injection-molding method so as to configure the support element specifically in such a manner that the support element in the form of a support ring connects in a form-fitting manner the hub and the gear rim, wherein the gear rim and the support element configure a multiplicity of teeth and the support element has support webs which penetrate the gear rim such that the radially outward pointing end sides of the support webs are exposed.

The gear rim is preferably configured in such a manner that the support ring in the cured state has undercuts which in the production permit jamming between the support ring and the gear rim.

The gear rim preferably has tooth elements which configure the tooth flanks of the teeth. It is preferable herein for one tooth element to configure in each case one tooth flank of two neighboring teeth. In this case it is advantageous for the support webs of the support element to be in each case disposed between two flanks of one tooth. The support webs thus lie between two tooth elements. The force acting on the toothing herein is absorbed not only by the support web but also by the two tooth elements adjacent to said support web.

In one preferred embodiment the support webs extend across the entire width of the worm gear in the region of the teeth, that is to say that the support webs in the direction of the longitudinal axis of the worm gear have the same width as the tooth flanks, or tooth elements, respectively. The force can thus be distributed in the best possible manner.

The support webs preferably have a consistent width.

An electro-mechanical motor vehicle steering device **1** having a steering wheel **2** which is coupled in a rotationally fixed manner to an upper steering shaft **3** and to a lower steering shaft **4** is schematically illustrated in FIG. **1**. The upper steering shaft **3** is functionally connected to the lower steering shaft **4** by way of a torsion bar **110**. The upper steering shaft **3** is connected in a rotationally fixed manner directly to the steering wheel. The lower steering shaft **4** along the worm gear longitudinal axis **121** thereof for engaging in a form-fitting manner with an articulated assembly has a partial toothing, said articulated assembly in turn being connected to a steering gear system by way of a shaft. The lower steering shaft **4** is connected in a rotationally fixed manner to a pinion **5**. The pinion **5** in a known manner meshes with a tooth segment of a rack **6**. The rack **6** is mounted in a steering housing so as to be displaceable in the direction of the longitudinal axis of said rack **6**. The rack **6** at the free end thereof by way of ball joints (not illustrated) is connected to tie rods **7**. The tie rods **7** per se in a manner known by way of steering knuckles are in each case connected to one steered wheel **8** of the motor vehicle. A rotation of the steering wheel **2**, by way of the connection of the steering shaft **3**, **4** and of the pinion **5**, leads to a longitudinal displacement of the rack **6** and thus to pivoting of the steered wheels **8**. The steered wheels **8** by way of a carriageway **80** are imparted a feedback effect which acts counter to the steering movement. A force which requires a corresponding torque at the steering wheel **2** is consequently required for pivoting the wheels **8**. An electric motor **9** of a servo unit **10** is provided for assisting the driver in this steering movement. The servo unit **10** herein can be disposed as a superimposed steering device on the steering column or as a power-assisted installation on the pinion **5** or on the rack **6**.

FIG. **2** shows a worm gear system **11** disposed in a housing **100**. A worm gear **12** which is connected in a rotationally fixed manner to the steering shaft **4**, for example, is provided. The worm gear **12** is driven by way of a worm **13** which in turn is driven by way of the electric motor **9**, wherein the drive output **14** of the electric motor **9** for transmitting torque is correspondingly coupled to the worm **13**. The worm **13** at both ends thereof is radially supported in the housing **100** by way of a roller bearing **130** and enables angular compensation.

The worm gear **12** having a hub **15**, a support ring **16**, and a gear rim **17** surrounding the support ring **16** is illustrated along the worm gear longitudinal axis **121** in FIG. **3**. The hub **15** herein is configured so as to be integral to the output shaft **4** and at the one end of said hub **15** has a toothing for the form-fitting connection to the articulated assembly and at the other side is open in the direction towards the input shaft **3** such that the torsion bar **110** can be introduced thereinto. The torsion bar **110** can also be introduced into the output shaft **4** by way of the end on which the articulated assembly is provided. As is illustrated in FIG. **9**, the output shaft has an internal contour in the shape of a cloverleaf so as to receive therein a shaft having a corresponding external contour.

As is shown in FIGS. **4** to **7**, an insert part **150** configures the hub **15**. The insert part **15** is preferably made from metal,

in particular steel. The insert part **150** has a gear rim **153** having a toothing **152** which is directed radially outward in terms of the worm gear longitudinal axis **121**. One injection bore **151** is in each case provided herein between two protrusions or teeth **152** of the gear rim **153**. According to this embodiment, the ratio between the protrusions **152** of the gear rim **153** and the injection bores **151** of the plastics-material gear rim **17** corresponds to a ratio of 1:2. In other words: One injection bore **151** is in each case provided between every other depression which is formed between two gear rim teeth **152**. The gear rim **17** is a single-component plastics material part. The gear rim **17** is preferably composed of a tough material which is not filled with glass fibers.

The support ring **16** connects the insert part **15** to the gear rim **17**. The support ring **16** on both end sides **122**, **123** has reinforcement ribs **161** which from an annular web **162** extend radially in the direction of a fastening region **163** having the insert part **15**. The reinforcement ribs have a consistent width a. The reinforcement ribs **161** protrude laterally from the main body of the support ring **16** but do not protrude beyond the width b of the worm gear in the region of the toothing **18**. A contour having protrusions and depressions in which the melt dwells during the injection-molding and fills the support ring **16** such that a defined fiber orientation can be enabled may be provided in the direction of the teeth **18** along the annular web **162**, so as to be opposite the reinforcement ribs. Proceeding from the annular web **162**, the support ring **16** has radially outwardly extending support webs **164** which form in each case a part of a tooth **18** of the worm gear **12**. The support webs **164** have a substantially consistent wall thickness d. The mutually opposite internal sides **165** of the support webs **164** lie against a corresponding counter piece of the gear rim **17**. The radially outwardly pointing end sides **166** of the support webs **164** herein are not covered by the gear rim **17** and configure the tooth tip **19** of the teeth **18**. The support ring **16** is preferably formed from a high-density, highly-oriented plastics material. Proceeding from the annular web **162** at the tooth root of the support ring **16**, connection elements **167** which are axially mutually opposite and which correspond with a connection structure **171** of the gear rim **17** and form a form-fit with the latter are provided.

The gear rim **17** on the inner circumferential face thereof in the direction of the insert part **15** has a connection protrusion **178** along which a single-row or multiple-row connection structure **171** is distributed on both end sides of the gear rim **17** and along the entire circumference. As is illustrated in FIG. **4**, the connection structure has a smaller width than the gear rim toothing and engages in a form-fitting manner in the connection elements **167** of the support ring. Tooth elements **172** which extend radially outward and which are preferably configured so as to be V-shaped or U-shaped having two legs **173** are adjacent to the connection structure **171** on the external side which extends across the circumference. The legs **173** in the region of the end sides **166** of the support web have radially outwardly pointing end sides **179** such that the end sides **166**, **179** conjointly configure the tooth tip **19** of the teeth **18**. The two legs **173** of the tooth elements **172** herein configure in each case one tooth flank **174** of two successive teeth **18**. The tooth flanks **174** have the contact faces **175** of the engagement mechanism with the worm. Recesses **176** which correspond with the support webs **164** of the support ring **16** are provided in the circumferential direction between the tooth elements **172**. The recesses **176** consequently have a spacing b such that the support webs **164** of the support ring can be received therein. The external sides **177** of the tooth elements **172** therefore extend substantially in the radial direction.

As is shown in FIG. **7**, the longitudinal axes **181** of the tooth elements **172**, or of the teeth, respectively, conjointly with the longitudinal axis **121** of the worm gear **12**, enclose an angle α. The angle α is preferably in a range between 13° and 20°; the angle is particularly preferably approx 15.5°.

FIGS. **8** to **12** show the completed worm gear **12** in detail. FIG. **11** shows a section through a tooth flank of the tooth element of the gear wheel **17** of the worm gear. A section through the worm gear in the region between the tooth flanks of two successive teeth is illustrated in FIG. **12**.

The gear rim **17** is preferably made by diaphragm gating. Flow marks or binding marks can thus be avoided. In a second production step, the gear rim **17** is positioned on the insert part **150**. The support ring **16** in an injection-molding method is injected between the insert part **150** and the gear rim **17**. To this end, the insert part **150** has injection bores **151** into which a plastics material for configuring the support ring **16** is injected. The gaps, or recesses, respectively, **176** present between the tooth elements **173** are closed on account of the injection of the support ring **16**. The support ring **16** thus reaches up to the toothing of the worm gear. The support webs **164** formed on account thereof extend continuously across the entire width b of the worm gear **12**, from one end side **122** of the worm gear **12** to the other end side **123**. The component is thus imparted a very high rigidity. The support ring **16** formed by injection-molding enables a form-fit between the gear rim **17** and the insert part **150**. Said support ring **16** is a highly rigid load-bearing structure which can be economically produced. A worm gear **12** having positive contact properties when engaging with the worm and a positive support structure is achieved on account of the choice of different materials for the support ring **17** and the gear wheel **16**.

What is claimed is:

1. A worm gear for a worm gear system of a motor vehicle steering device, the worm gear comprising:

a hub;

a gear rim; and

a support element configured as a support ring that is injection molded between the gear rim and the hub so as to connect the gear rim and the hub in a form-fitting manner, wherein the gear rim and the support element configure teeth, wherein the support element has support webs that penetrate the gear rim such that radially outward pointing end sides of the support webs are exposed, wherein the support webs extend across an entire width of the worm gear in a region of the teeth.

2. The worm gear of claim **1** wherein the gear rim includes tooth elements configured as tooth flanks of the teeth.

3. The worm gear of claim **2** wherein in each case one of the tooth elements is configured as one of the tooth flanks of two neighboring teeth of the teeth.

4. The worm gear of claim **1** wherein the support webs have a constant width.

5. The worm gear of claim **1** wherein the support webs extend in a radially outward direction from an annular web of the support element.

6. The worm gear of claim **1** wherein the gear rim is a single-component plastics material part.

7. The worm gear of claim **1** wherein the hub is configured as an insert part that has injection bores that are configured for injecting plastic for configuring the support ring.

8. A method for producing a worm gear for a worm gear system of a motor vehicle steering device, the method comprising:

providing a hub of the worm gear, the hub being configured as an insert part;

inserting the insert part into a gear rim of the worm gear; and

injecting plastic between the gear rim and the insert part by way of injection molding to configure a support element of the worm gear as a support ring that connects in a form-fitting manner the hub and the gear rim, wherein the gear rim and the support element configure teeth, wherein the support element includes support webs that penetrate the gear rim such that radially outward pointing end sides of the support webs are exposed,

wherein the gear rim has tooth elements that configure tooth flanks of the teeth, wherein the support webs are in each case disposed between two of the tooth flanks of one of the teeth.

9. The method of claim **8** wherein in each case one of the tooth elements is configured as one of the tooth flanks of two neighboring teeth of the teeth.

10. The method of claim **8** wherein the support webs extend across an entire width of the worm gear in a region of the teeth.

11. The method of claim **8** wherein the support webs have a constant width.

12. A worm gear for a worm gear system of a motor vehicle steering device, the worm gear comprising:

a hub;

a gear rim; and

a support element configured as a support ring that is injection molded between the gear rim and the hub so as to connect the gear rim and the hub in a form-fitting manner, wherein the gear rim and the support element configure teeth, wherein the support element has support webs that penetrate the gear rim such that radially outward pointing end sides of the support webs are exposed,

wherein the gear rim includes tooth elements configured as tooth flanks of the teeth, wherein in each case one of the tooth elements is configured as one of the tooth flanks of two neighboring teeth of the teeth, wherein the support webs are in each case disposed between two of the tooth flanks of one of the teeth.

13. The worm gear of claim **12** wherein the support webs extend across an entire width of the worm gear in a region of the teeth.

14. The worm gear of claim **12** wherein the support webs have a constant width.

15. The worm gear of claim **12** wherein the support webs extend in a radially outward direction from an annular web of the support element.

16. The worm gear of claim **12** wherein the gear rim is a single-component plastics material part.

17. The worm gear of claim **12** wherein the hub is configured as an insert part that has injection bores that are configured for injecting plastic for configuring the support ring.

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